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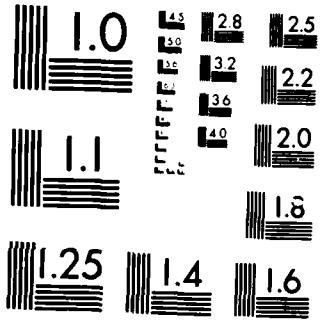

TECHNICAL REPORT ARLCD-CR-84016

M577 FUZE PRODUCT IMPROVEMENT PROGRAM: ALTERNATE MATERIALS FOR OGIVE WINDOW

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this project was to provide an alternate plastic material for the ogive window that would be lower in cost than the current polycarbonate window, resist crazing and discoloration, and be capable of being ultrasonically bonded. Sixteen materials were identified for evaluation and are discussed in this report.

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INTRODUCTION

The objective of this project was to provide an alternate plastic material for the ogive window which would be lower in cost than the current polycarbonate window and which would also resist crazing and discoloration.

When work started on this task in early 1981, epoxy was being used on the Hamilton Technology, Inc. (HTI) production line to attach and seal the polycarbonate window to the ogive. Near the end of 1981, the production line began the implementation of VEP A9A8702 which called for the window to be ultrasonically bonded to the ogive. This change, from epoxy bonding to ultrasonic bonding, generated an additional requirement for this task that had not been considered originally. That is, any plastic selected as a replacement material for the window would have to be compatible with the ultrasonic bonding process.

In pursuit of this task, an extensive search was conducted to identify suitable transparent plastics. Sixteen materials were identified for evaluation.

TECHNICAL DISCUSSION

The original objective was to provide an alternate ogive window material which would reduce the cost of the window and resist crazing and discoloration. Later in the program, the objective was modified to include a change which required any window material to be ultrasonically bondable to the ogive.

In pursuit of the objective, an extensive literature search was conducted to identify suitable transparent plastics. Manufacturers, vendors, and plastic consultants were contacted for their assistance in this search. As a result of this effort, 12 transparent plastic materials were identified and selected for further evaluation.

A study, conducted by the Organic Branch of the Materials Laboratory of ARRADCOM in 1978, identified three transparent plastic materials for consideration as ogive window material. These three materials, ionomer, acrylic, and PVC, along with the 12 materials identified by the HTI search and the current polycarbonate window material, comprised the 16 transparent plastic materials evaluated and documented in this report. These 16 sixteen materials along with the manufacturer and the manufacturer's trade name are listed in table 1.

Evaluations of Materials

Each of these 16 plastic materials was evaluated for the following characteristics or factors:

(1) Cost

(2) Optical clarity

(3) Ultrasonic bondability

(4) Resistance to aging (crazing and discoloration)

(5) Temperature stability -65^{o}F to +165^{o}F

(6) Strength and hardness

(7) Resistance to hydrocarbon oils or solvents

The results of this evaluation are shown in table 2.

Table 1. Materials tested for acceptability

Trade name	Type of plastic	Manufacturer
Lexan 141	Polycarbonate	General Electric
Cellulose Butyrate	Cellulosics	Eastman
Plexiglas V811-100	Acrylic	Rohm & Haas
Plexiglas DR-100	Acrylic	Rohm & Haas
Lucite 147	Acrylic	Dupont
Udel	Polysulfone	Union Carbide
Styron 685D	Polystrene	Dow
Tyril	Strene-Acrylonitrile	Dow
K-Resin	Butadine Styrene	Phillips Chemical
CR-39	Allyl Diglycol Carbonate	PPG
Trogamid T	Polyamide	Dynamite Noble
Kel-F	Teflon	3M
Ultem	Nylon	Dupont
Surlyn 1706	Ionomer	Dupont
Surlyn 1707	Ionomer	Dupont
Ethyl 7053, 7051	Polyvinyl Chloride	Ethyl

Five of the 16 materials being evaluated were too costly for implementation as a replacement material. These materials were polysulfone, allyl diglycol carbonate, polyamide, teflon, and nylon. Windows made from these materials would be from two to four times as costly as the present polycarbonate window. The other 11 materials would be cost competitive at about $0.055 each.

All of the 16 materials are optically clear under ambient conditions except Udel polysulfone and Ultem nylon. Both of these materials have a slight amber tint, the nylon being somewhat darker than the polysulfone. Because of this amber tint condition, the use of either of these plastics in a window would be questionable.

The remaining evaluations of the various materials, as shown in table 2, are primarily based on information received from the manufacturers of the materials. From the information in this table, it was determined that Surlyn 1706, cellulose butyrate, and plexiglas V811-100 were three possible replacement materials which would satisfy the functional requirements and be cost effective. After further review, these materials were chosen before the requirement to ultrasonically bond the window to the ogive was added. The Surlyn 1706 was eliminated because the functional temperature range was not acceptable.

Possible Replacements

Plexiglas V811-100, a colorless acrylic, was chosen because of its optical qualities and resistance to lubricants. This acrylic plastic resists discoloration or loss of light transmission under long-term exposure to severe environments including sunlight. The acrylic exhibited a higher resistance to astro oil than the present polycarbonate material. The acrylic material was subjected to a film of astro oil for several days at room temperature without hazing. The present polycarbonate material hazed after a 24-hour exposure.

Ogive windows made of this acrylic plastic were injected molded using the present production ogive window mold. Fuzes with acrylic windows epoxied in the ogive were subjected to various environment tests plus air gun testing with satisfactory results. However, when the ultrasonic bonding requirement was added to this task, it was found the material could not be bonded satisfactorily with the current ultrasonic bonding equipment. The development of an ultrasonic bonding process for acrylic plastic was not considered, since acrylic offers no significant cost savings over the present polycarbonate material.

Cellulose butyrate was selected for further testing because of its chemical resistance and weatherability. When exposed to astro oil for 24 hours, the cellulose material was not affected as much as the present polycarbonate material.

Table 2

	MATERIALS TESTED FOR ACCEPTABILITY			EVALUATION FACTORS						
	Trade Name	Type of Plastic	Manufacturer	Est. Cost Each Window (Dollars)	Resistance to Oil & Solvents When in Direct Contact	Clarity with Age	Ability to Function from -65°F to 165°F	Anti-crazing Characters	Strength & Hardness	Compatible with Ultrasonic Bonding
1.	Lexan 141	Polycarbonate	General Electric	.055	A	G	E	A	E	G
2.	Cellulose Butyrate	Cellulosics	Eastman	.055-.060	G	G	G	G	G	P
3.	Plexiglas V811-100	Acrylic	Rohm & Haas	.050-.055	G	E	A	G	E	P
4.	Plexiglas DR-100	Acrylic	Rohm & Haas	.050-.055	G	E	A	G	A	P
5.	Lucite 147	Acrylic	Dupont	.055	G	G	A	G	G	P
6.	Udel	Polysulfone	Union Carbide	>.10	G	A	G	A	E	P
7.	Styron 685D	Polystrene	Dow	.050-.055	P	A	P	P	G	P
8.	Tyril	Strene-Acrylonitrile	Dow	.050-.055	P	A	P	P	E	P
9.	K-Resin	Butadine Styrene	Phillips Chemical	.050-.055	P	A	P	P	A	P
10.	CR-39	Allyl Diglycol Carbonate	PPG	.15	E	E	E	E	A	P
11.	Trogamid T	Polyamide	Dynamite Noble	>.10	E	E	E	E	E	G
12.	Kel-F	Teflon	3M	>.20	E	E	E	E	E	A
13.	Ultem	Nylon	Dupont	>.10	E	A	E	E	E	G
14.	Surlyn 1706	Ionomer	Dupont	.050-.055	E	E	P	G	A	P
15.	Surlyn 1707	Ionomer	Dupont	.050-.055	E	E	P	G	A	P
16.	Ethyl 7053, 7051	Polyvinyl Chloride	Ethyl	.050-.055	A	P	P	A	A	P

KEY: E - Excellent
G - Good
A - Average
P - Poor

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Sample ogive windows were injected with cellulose material using the present production mold. Fuzes with cellulose windows epoxied in the ogive were subjected to various environmental tests plus air gun testing with successful results. Cellulose windows were ultrasonically bonded to the ogive with unsatisfactory results. The cellulose was too soft and consequently would melt around the seal even with the lowest available horn pressure. In addition, the estimated cost of a cellulose ogive window is slightly higher than windows made from the present polycarbonate material.

Improvements to Present Window

Since it is not cost effective to replace the polycarbonate window with another material, improvements to the present window were investigated. The improvements considered were coating the window with a chemical resistant film and improving the injection molding process.

Several coatings for the window were tried. Samples of coated polycarbonate windows received from Air Locke Corporation were tested for chemical resistance with excellent results. These coated windows showed no hazing after subjection to a film of fuze lubricants after 24 hours even at high temperatures. The uncoated polycarbonate material withstood this test for only 4 hours. The lowest quote received for this coating process was $0.28 per window. Although this coating did improve the chemical resistance of the polycarbonate window, it was not considered feasible because of its high cost of application.

Another coating known as Rhoplex AC-868 was applied in-house. The optical properties of the window decreased after application of the coating; therefore, no further testing of this coating was done.

Improvements to the present polycarbonate window by modifying the design were discussed with the present vendor. Several steps could be taken to improve the optical performance and reduce the cost of the window.

The thickness of the window could be decreased by removing material on the inside surface of the window (figs. 1 and 2). The distortion from having a curved window would be decreased. In addition, the cost would be decreased because of using less material and a decrease in molding cycle time. Changing the mold to accommodate this design change would cost approximately $8,000, the projected cost savings per window is less than $0.01.

Another improvement to the window could be obtained by changing the gate in the mold. Moving the gate to the lower end of the window from its current location at the side would provide better material flow and quicker separation of the part from the runner. The gate of the mold could also be made thicker to allow a greater flow of material. This would reduce the internal stresses in the window; thus, the window would not craze as quickly or easily. The cost of modifying the mold to change the gate location and size would cost from $10,000 to $12,000.

Improvements to the present ogive window can be made but the cost of the mold changes outweighs the benefit.

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TESTING

Air Gun Test

Five cellulose and five acrylic windows in fuzes were air gun tested from 26,600 g to 34,000 g setback. Both materials were epoxied into the ogive. Some windows of each material exhibited slight damage, but no more damage than observed on the present polycarbonate material after air gun tests. Unit by unit data is given in table 3.

Table 3. Air Gun Test

Unit	Window material	g level	Observation
1	Cellulose	33,899	No visual effect
2	Cellulose	31,102	No visual effect
3	Cellulose	33,759	Indentation of window
4	Cellulose	26,627	Indentation of window
5	Cellulose	31,522	No visual effect
6	Acrylic	31,102	Seal of window broken
7	Acrylic	31,522	Seal of window broken
8	Acrylic	30,962	Seal of window broken
9	Acrylic	32,501	No visual effect
10	Acrylic	30,683	No visual effect

Waterproofness Test

Twenty units, ten each with cellulose and acrylic ogive windows, were tested per MIL-F-50983, Paragraph 3.8. The windows were assembled to the ogive using the ultrasonic bonding process. One unit that contained a cellulose window leaked around the window surface. The cellulose material showed signs of melting where the ultrasonic bonding took place. This melting did not allow the window and ogive to seal properly.

CONCLUSIONS AND RECOMMENDATIONS

After carefully reviewing the data, Hamilton Tehnology, Inc. concluded that the present poycarbonate material meets the overall objectives of this task better than any of the materials evaluated, even though some of the other materials have a superior rating in some of the categories. All materials except for cellulosics and the acrylics were rejected because of cost or unacceptable functioning temperature range. The acrylics and cellulosics materials were rejected due to poor ultrasonic bonding capability.

Hamilton Technology, Inc. recommends there be no change to the ogive window material.

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